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VOLUME I

PROPOSED MIL STANDARD AND HANDBOOK — FLYING QUALITIES OF AIR VEHICLES

Volume I: Proposed MIL Standard

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This report is published to elicit comments, and suggestions, for adopting or revising the material which the Government will incorporate into an official MIL Standard and Handbook. As it stands, the material is preliminary and occasionally controversial, does not in all cases represent the views of the Government or a particular Government organization, and should not be used for procurement. This report does not reflect our work in progress on flying qualities requirements for large airplanes, direct force controllers or STOL aircraft.

This report has been reviewed by the Office of Public Affairs (ASD/PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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MIL-F-8785C, "Military Specification, Flying Qualities of Piloted Airplanes", has been revised into a MIL Standard and supporting Handbook. This report is a proposed version of the MIL Standard and Handbook developed by Systems Technology, Inc., with the McDonnell Aircraft Co. acting in a consulting role. This report is published to elicit comments, and suggestions, for adopting or revising the material which the Government will incorporate into an official MIL Standard and Handbook. As it stands, the material is preliminary and

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FOREWORD

The work reported herein was performed during the period from April 1980 to July 1982 under Contract F33615-80-C-3604 from the Air Force Wright Aeronautical Laboratories, Air Force Systems Command. Lieutenant Robert B. Crombie was the initial project engineer. This responsibility was later transferred to Captain Stanley G. Fuller. This work was completed under Program Element 61102F, Project 2403, Task 05, and Work Unit 40. The STI technical director was Mr. Irving L. Ashkenas. Mr. Roger H. Hoh served as STI project engineer.

The authors wish to express their gratitude to the many reviewers in industry and government who offered beneficial comments on various portions of this report. Special thanks are extended to Messrs. David J. Moorhouse and Robert J. Woodcock of AFWAL for their significant contributions.

We wish also to thank our co-workers at both STI and McDonnell Aircraft Company for their support.

Finally, appreciation is extended to the STI Editorial Department, and especially Mss. Linda Huffman and Kay Wade and Mr. Charles Reaber, for their outstanding work in all phases of production of this report.

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SECTION - INTRODUCTION

1. SCOPE OF THE REPORT

MIL-F-8785C, Military Specification -- Flying Qualities of Piloted Airplanes, has been reformatted into a MIL Standard and a supporting MIL Handbook. This report is a draft of the proposed MIL Standard, which has been developed by Systems Technology, Inc., with the McDonnell Aircraft Company acting in a consulting role. It is presented to industry and the United States armed forces for comments and proposed revisions. The responsibility for the legal MIL Standard and Handbook rests within the armed forces. This draft will be considered and form the basis for revisions, industry and government comments and a tri-service review in the process of developing the MIL Standard and Handbook. The MIL Standard is presented in this volume.

MIL-F-8785C and the backup documents to both it and its predecessor, MIL-F-8785B, were reviewed extensively. Much of the material contained therein is still considered to be valid and relevant and has been retained in this document.

2. CONCEPT OF MIL STANDARD AND HANDBOOK

The MIL Standard is a skeleton document consisting of incomplete requirements in verbal form which are to be completed by the procuring activity using numerical criteria from the MIL Handbook. A custom MIL Standard will be developed for each new aircraft procurement or major modification of an existing aircraft, as follows:

1) Identify mission requirements.

2) Break down requirements into piloting tasks.

3) For each paragraph in the MIL Standard, select the most appropriate handling quality criterion from the MIL Handbook and insert into the Standard.

The procedure results in a customized handling quality specification for each new aircraft or modification of an existing aircraft. The purpose of this revised format is to facilitate tailoring a detailed handling quality specification to the particular mission requirements of the aircraft being acquired.

The reader is referred to Volume II of this report for further discussion on the organization and rationale for the Standard and Handbook.

SECTION 1

1. SCOPE AND OPERATIONAL OBJECTIVES

1.1 Scope. This specification contains the requirements for the flying and ground handling qualities of a U.S. military aircraft. It is intended to assure flying qualities for adequate mission performance and flight safety regardless of the design implementation or flight control system augmentation.

1.2 Application. The flying qualities of the aircraft proposed or contracted for shall be in accordance with this specification. The requirements are written in terms of the axis of vehicle motion and include all aspects of control for that axis, as well as vehicle responses to other inputs, e.g., turbulence, store release, etc. This approach therefore includes requirements for other (i.e., secondary) methods of control for a given axis (DLC, speed brakes, etc.). The requirements apply, as stated, to the combination of airframe and related subsystems. This includes stability augmentation and flight control systems (automatic and/or manual), when provided.

1.3 Aircraft Classification and Operational Missions. For the purpose of this Standard, the aircraft specified in this requirement is to accomplish the following missions: ________________. The aircraft thus specified will be a Class ___ aircraft.

1.4 Flight Phase Categories. To accomplish the mission requirements the following general Flight Phase categories are involved: ______________________________. Special Flight Phases to be considered are: ________________________.

1.5 Flight Envelopes

1.5.1 Operational Flight Envelopes. The Operational Flight Envelopes define the boundaries in terms of speed, altitude and load factor within which the aircraft must be capable of operating in order to accomplish the missions of Paragraph 1.3. Envelopes for each applicable Flight Phase are as follows: ___________. In the absence of the above, the contractor shall use the representative conditions of Table 1 of the Handbook for the applicable Flight Phases.

1.5.2 Service Flight Envelopes. For each Aircraft Normal State the contractor shall establish, subject to the approval of the procuring activity, Service Flight Envelopes showing combinations of speed, altitude, and normal acceleration derived from aircraft limits as distinguished from mission requirements. For each applicable Flight Phase and Aircraft Normal State, the boundaries of the Service Flight Envelopes

can be coincident with or lie outside the corresponding Operational boundaries. The boundaries of the Service Flight Envelopes shall be based on considerations discussed in the Handbook.

1.5.3 Permissible Flight Envelopes. The contractor shall define Permissible Flight Envelopes which encompass all regions in which operation of the aircraft is both allowable and possible, and which the aircraft is capable of safely encountering. These Envelopes define boundaries in terms of speed, altitude, and load factor.

1.6 State of the Aircraft

1.6.1 Aircraft Normal States. The contractor shall define and tabulate all pertinent items to describe the Aircraft Normal States (no component or system failure) associated with each of the applicable Flight Phases. This tabulation shall be in the format of Table 1 and shall use the nomenclature specified in 4.2. Certain items, such as weight, moments of inertia, center-of-gravity position, wing sweep, or thrust setting may vary continuously over a range of values during a Flight Phase. The contractor shall replace this continuous variation by a limited number of values of the parameter in question which will be treated as specific States, and which include the most critical values and the extremes encountered during the Flight Phase in question.

1.6.2 Aircraft Failure States. The contractor shall define and tabulate all Aircraft Failure States, which consist of Aircraft Normal States modified by one or more malfunctions in aircraft components or systems; for example, a discrepancy between a selected configuration and an actual configuration. Those malfunctions that result in center-of-gravity positions outside the center-of-gravity envelope defined in 3.1.1 shall be included. Each mode of failure shall be considered. Failures occurring in any Flight Phase shall be considered in all subsequent Flight Phases.

1.6.3 Aircraft Special Failure States. Certain components, systems, or combinations thereof may have extremely remote probability of failure during a given flight. These failure probabilities may, in turn, be very difficult to predict with any degree of accuracy. Special Failure States of this type need not be considered in complying with the requirements of Section 3 if justification for considering the Failure States as Special is submitted by the contractor and approved by the procuring activity.

1.7 Levels of Flying Qualities. The acceptability of the handling characteristics of an aircraft are quantified herein in terms of "Levels" that are defined as ____________. Where possible, the requirements of Section 3 are stated in terms of three limiting values of one or more flying quality parameters. Each value, or combination of values, represents a minimum condition necessary to meet one of the three "Levels" of acceptability.

In some cases sufficient simulation or flight test data do not exist to allow the specification of numerical values of a flying quality parameter. In such cases it is not possible to explicitly define the lower boundary of each Level. These cases are handled by stating the required "Level" of flying qualities for specified piloting tasks, which require compliance by demonstration in flight or via piloted simulation.

It is expected that flying qualities will degrade with increasing atmospheric disturbances and/or Aircraft Failure States. To account for this, the Levels will be adjusted as a function of turbulence magnitude and failures. These adjustments to the definition of flying quality Levels are to be used for those requirements where numerical values are not specifically stated. The adjusted Level definitions should not be construed as a recommendation to degrade flying qualities with increasing values of atmospheric disturbances.

The requirements for aircraft Levels as a function of flight envelopes and failure states are presented in Paragraph 3.1.5. The effect of atmospheric disturbances on Levels is given in Paragraphs 3.9.1 and 3.9.4.

SECTION 2

2. APPLICABLE DOCUMENTS. The following specifications and standards, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein. Copies of specifications and standards required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.

Specifications: ______________________________

Standards: ___________________________________

SECTION 3

3. REQUIREMENTS

3.1 GENERAL REQUIREMENTS

3.1.1 Loadings. The envelope of center of gravity and weight for each flight phase shall be specified by the contractor. In addition, the contractor shall specify the maximum c.g. excursion attainable through failure in systems or components for each flight phase.

3.1.2 Moments and Products of Inertia. The contractor shall define the moments and products of inertia of the aircraft associated with all loadings of 3.1.1. The requirements of this specification shall apply for all moments and products of inertia so defined.

3.1.3 External Stores. The external stores and store combinations to be considered are as follows: ______________________. The requirements of this Standard shall apply to these store conditions. The effects of external stores on the weight, moments of inertia, center of gravity position, and aerodynamic characteristics of the aircraft shall be considered for each mission Flight Phase. When the stores contain expendable loads, the requirements of this Standard apply throughout the range of store loadings.

3.1.4 Configurations. The requirements of this specification shall apply for all configurations required or encountered in the applicable Flight Phases of Section 1.4. A configuration is defined by the positions and adjustments of the various selectors and controls available to the crew except for pitch, roll, yaw, throttle and trim controls. Examples are: the flap control setting and the yaw damper ON or OFF. The selected configurations to be examined must consist of those required for performance and mission accomplishment. Additional configurations to be investigated are defined as follows: ______________________. Control positions which activate stability augmentation necessary to meet the requirements of this standard are considered to be always on unless otherwise specified.

3.1.5 Allowable Levels for Aircraft Normal States

3.1.5.1 Within Operational Flight Envelopes. The minimum required flying qualities for the Aircraft Normal State within the Operational Flight Envelope will be Level ____. To account for degradation in handling qualities due to atmospheric disturbances the requirements will be adjusted as a function of disturbance magnitude according to the requirements of Paragraph 3.9.1.

3.1.5.2 Within Service Flight Envelopes. The minimum required flying qualities for the Aircraft Normal State within the Service Flight Envelope but outside the Operational Flight Envelope will be Level ____.

3.1.5.3 Within Permissible Flight Envelopes. From all points in the Permissible Flight Envelopes and outside the Service Flight Envelope, it shall be possible readily and safely to return to the Service Flight Envelope without exceptional pilot skill or technique. The requirements on flight at high angle of attack, dive characteristics, dive recovery devices and dangerous flight conditions shall also apply.

3.1.5.4 For ground operation. Some requirements pertaining to taxiing involve operation outside the Operational, Service, and Permissible Flight Envelopes, as at V_s or on the ground. When requirements are stated at conditions such as these, the Levels shall be applied as if the conditions were in the Operational Flight Envelope.

3.1.6 Allowable Levels for Aircraft Failure States

3.1.6.1 Probability Calculation. When Aircraft Failure States exist (1.6.2), a degradation in flying qualities is permitted only if the probability of encountering a lower Level than specified in Para. 3.1.5 is sufficiently small. The contractor shall determine, based on the most accurate available data, the probability of occurrence of each Aircraft Failure State per flight hour within the Operational and Service Flight Envelopes. Each specific failure is assumed to be present at whichever point in the Flight Envelope being considered is most critical (in the flying qualities sense). From these Failure State probabilities and effects, the contractor shall determine the overall probability, per flight hour, that one or more flying qualities are degraded to Level 2 because of one or more failures. The contractor shall also determine the probability that one or more flying qualities are degraded to Level 3. These probabilities shall be less than the values shown in Table 1.

TABLE 1 (3.1.6.1)

LEVELS FOR AIRCRAFT FAILURE STATES

PROBABILITY OF ENCOUNTERING	WITHIN OPERATIONAL FLIGHT ENVELOPE	WITHIN SERVICE FLIGHT ENVELOPE
Level 2 after failure	< ____ per flight hr	
Level 3 after failure	< ____ per flight hr	< ____ per flight hr

3.1.6.2 Generic Failure Analysis. The allowable Flying Quality Levels for each of the Failure States in Paragraph 1.6.2 are defined as follows: ______________________.

3.1.7 Dangerous Flight Conditions. Dangerous conditions may exist where the aircraft should not be flown. When approaching these flight conditions, it shall be possible by clearly discernible means for the pilot to recognize the impending dangers and take preventive action.

3.1.7.1 Warning and indication. Warning and indication of approach to a dangerous condition shall be clear and unambiguous. For example, a pilot must be able to distinguish readily among stall warning (which requires pitching down or increasing speed), Mach buffet (which may indicate a need to decrease speed), and normal aircraft vibration (which indicates no need for pilot action).

3.1.7.2 Devices for indication, warning, prevention, recovery. It is intended that dangerous flight conditions be eliminated and the requirements of this specification met by appropriate aerodynamic design and mass distribution, rather than through incorporation of a special device or devices. As a minimum, these devices shall perform their function whenever needed but shall not limit flight within the Operational Flight Envelope. Neither normal nor inadvertent operation of such devices shall create a hazard to the aircraft. For Levels 1 and 2, nuisance operation shall not be possible. Functional failure of the devices shall be indicated to the pilot.

3.1.8 Interpretation of Subjective Requirements. In several instances throughout the specification subjective terms, such as objectionable flight characteristics, realistic time delay, normal pilot technique and excessive loss of altitude or buildup of speed, have been employed where insufficient information exists to establish absolute quantitative criteria. Final determination of compliance with requirements so worded will be made by the procuring activity.

3.1.9 Interpretation of Quantitative Requirements. The numerical requirements of this specification generally are stated in terms of a linear mathematical description of the aircraft. Certain factors, for example flight control system nonlinearities and higher-order characteristics or aerodynamic nonlinearities, can cause the aircraft response to differ significantly from that of the linear model. The contractor shall determine equivalent classical systems which have responses most closely matching those of the actual aircraft. Then those numerical requirements of Section 3 which are stated in terms of linear system parameters (such as frequency, damping ratio and modal phase angles) apply to the parameters of that equivalent system rather than to any particular modes of the actual higher-order system. The adequacy of the response match between equivalent and actual aircraft shall be agreed upon by the contractor and the procuring activity.

3.1.10 Quality Assurance

3.1.10.1 Compliance demonstration. Compliance with the quantitative requirements of Section 3 shall be demonstrated through analysis. In addition, compliance with many of the requirements will be demonstrated by simulation, flight test, or both. The methods for demonstrating compliance shall be established by agreement between the procuring activity and the contractor. Representative flight conditions, configurations, external store complements, loadings, etc., shall be determined for detailed investigations in order to restrict the number of design and test conditions. The selected design points must be sufficient to allow accurate extrapolation to the other conditions at which the requirements apply.

a) Analysis. The analytical methods, procedures, assumptions, etc., applied shall be made available to the procuring activity. In some instances (e.g., control power) compliance may be demonstrated partially or wholly by analysis when the analytical model is validated with flight test data and approved by the procuring activity. In other instances (e.g., control in turbulence) analysis will provide information on specific test conditions requiring simulation, flight test, or both.

b) Simulation. The danger, extent or difficulty of flight testing may dictate simulation rather than flight test to evaluate some conditions and events, such as the influence of Severe disturbances, events close to the ground (except 3.2.8.4 shall be demonstrated in flight), combined Failure States and disturbances, etc. In addition, by agreement with the procuring activity, piloted simulation shall be performed before first flight of a new aircraft design in order to demonstrate the suitability of the handling qualities, and also to demonstrate compliance with qualitative requirements in atmospheric disturbances. Where simulation is the ultimate method of demonstrating compliance for a requirement, the simulation model shall be validated with flight test data.

c) Flight test. The required flight tests will be defined by operational, technical, and safety considerations as decided jointly by the procuring activity, the test agency, the contractor, and other involved agencies using results from 3.1.10.1a and 3.1.10.1b. It is expected that flight test demonstration of the requirements in calm air and selected requirements in at least Moderate turbulence will be accomplished

3.1.10.2 Design and test conditions. Table 1 specifies general guidelines, but the peculiarities of the specific aircraft design may require additional or alternate test conditions.

a) Terms specified in Table 1 such as "heaviest weight" and "greatest moment of inertia" mean the heaviest and greatest consistent with 3.1.1 and 3.1.2. When a critical center-of-gravity position is identified, the aircraft weight and associated moments of inertia shall correspond to the most adverse service loading in which that critical center-of-gravity position is obtained.

b) Terms specified in Table 1 such as "most forward c.g." and "most aft c.g." mean the most forward or most aft consistent with 3.1.1. When a critical weight or moment of inertia is identified, the center-of-gravity position shall correspond to the most adverse service loading in which that critical weight or moment of inertia is obtained.

c) For terminal Flight Phases, it will normally suffice to examine the selected Aircraft States at only one altitude below 10,000 feet (low altitude). For nonterminal Flight Phases, it will normally suffice to examine the selected Aircraft States at one altitude below 10,000 feet or at the lowest operational altitude (low altitude), the maximum operational altitude ($h_{o_{max}}$), and one intermediate altitude. When the maximum operational altitude is above 40,000 feet or when stability or control characteristics vary rapidly with altitude, more intermediate altitudes than specified in Table 1 shall be investigated. When the Service Flight Envelope extends far above or below the Operational Flight Envelope, the service-altitude extremes must be considered.

d) In addition to the flight conditions indicated in Table 1, speed-altitude combinations that result in the following shall all be investigated, where applicable:

- Maximum normal acceleration response per degree of controller deflection.
- Maximum normal acceleration response per pound of control force.
- Highest dynamic pressure and highest Mach number.

3.2 HANDLING QUALITY REQUIREMENTS FOR PITCH AXIS

3.2.1 Pitch Attitude Response to Pitch Controller

3.2.1.1 Pitch axis lower-order equivalent systems requirements. The equivalent parameters describing the responses of pitch rate and normal load factor (at the center of rotation) to a pitch control force input shall have the following characteristics: __________________.

TABLE 1 (3.1.10.2) DESIGN AND TEST CONDITION GUIDELINES

REQUIREMENT NUMBER	TITLE	CRITICAL LOADING	LOAD FACTOR	ALTITUDE	SPEED	FLIGHT PHASE
Section 3.2	HANDLING QUALITY REQUIREMENTS FOR PITCH AXIS					
3.2.1	Response to Pitch Controller	Most forward c.g. † and most aft c.g. §	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	*,CR,RT,PA L,CT
3.2.2	Pilot-Induced Oscillations	--	Minimum permissible to maximum permissible			
3.2.3	Residual Oscillations		1.0		$V_{o_{min}}$ to $V_{o_{max}}$	*,PA
3.2.7.2	Response to failures		All	$h_{o_{min}}$ and $h_{o_{max}}$	V_{min} to V_{max}	--
3.2.7.3	Response to configuration or control mode change		1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$		
3.2.7.4	Response to stores release		$n_o(-)$ to $n_o(+)$		$V_{o_{min}}$ to $V_{o_{max}}$	CO,GA,WD, AD
3.2.7.5	Response to armament delivery					*,RT
3.2.7.6	Response to buffet					*
3.2.8.1	Control power in unaccelerated flight	Most forward c.g.	1.0		V_{min} to V_{max}	--
3.2.8.2	Control power in maneuvering flight	Most forward c.g. †	As required		$V_{o_{min}}$ to $V_{o_{max}}$	CO,GA,AR, TF,CR,PA
3.2.8.3	Control power for takeoff	Most forward c.g. (nose-wheel), most aft c.g. (tail-wheel aircraft)	1.0	Low	As required	TO
3.2.8.4	Control power for landing	Most forward c.g.	1.0	Low	$V_S(L)$ or geometric limit	L
3.2.8.5	Control power for other conditions	--	All	$h_{o_{min}}$, medium, $h_{o_{max}}$	All	--
3.2.9.1	Steady-state control force per g	Most forward c.g. † and most aft c.g. §	$n(-)$ to $n(+)$		V_{min} to V_{max}	*,RT,CR,PA L,CT
3.2.9.2	Transient control force per g	Most aft c.g. §	1.0			--
3.2.9.3	Control force variations during rapid speed charges	--	As required		$V_{o_{min}}$ to $V_{o_{max}}$ and transonic	CO,GA,DE
3.2.9.4.1	Control force vs. deflection -- steady-state gradient	Most forward c.g. †	$n_o(-)$ to $n_o(+)$		V_{min} to V_{max}	*,RT,CR,PA, L,CT
3.2.9.4.2	Transient control force vs. deflection	Most aft c.g. §	1.0			--
3.2.9.5	Control centering and breakout forces	--	$n_o(-)$ to $n_o(+)$	$h_{o_{min}}$ and $h_{o_{max}}$		
3.2.9.6	Free play					
3.2.9.7.1	Force limits -- takeoff	Most forward c.g. and most aft c.g.	As required	Low	0 to V_{max}(TO)	TO,CT

† Combined with heaviest weight.

§ Combined with lightest weight.

* All applicable Category A Flight Phases.

-- No general guidance can be provided.

"As required" -- flight conditions are specified in requirement or are determined by nature of test maneuver.

TABLE 1 (3.1.10.2). (Continued)

REQUIREMENT NUMBER	TITLE	CRITICAL LOADING	LOAD FACTOR	ALTITUDE	SPEED	FLIGHT PHASE
3.2.9.7.2	Force limits -- landing	Most forward c.g.	1.0	Low	$V_S(L)$ or geometric limit	L
3.2.9.7.3	Force limits -- dives: SFE	Most forward c.g. † and most aft c.g. §	As required	2000 ft MSL to h_{max}	V_{min} to V_{max}	D,ED,CO, CR,GA
	PFE	↓	↓	As required	V_{MAT} to maximum permissible	↓
3.2.9.7.4	Force limits -- sideslips	--	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	CO,CR,PA,L
3.2.9.7.6	Force limits -- failures	--	All	$h_{o_{min}}$ and $h_{o_{max}}$	V_{min} to V_{max}	--
3.2.9.7.7	Force limits -- configuration or control mode charge	↓	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	↓	↓
3.2.9.8	Trim systems	Most forward c.g. and most aft c.g.	↓	↓	↓	↓
3.2.9.8.1	Trim systems -- rate of operation	--	↓	As required	As required	D,ED,CO, GA
3.2.9.8.2	Trim systems -- stalling of trim systems	Most forward c.g. †	As required	↓	Start of dive recovery to V_{max}	D,ED,CO, CR
3.2.9.8.3	Trim systems -- irreversibility	--	1.0	MSL to h_{max}	V_{min} to V_{max}	--
3.2.10.1	Control displacements -- takeoff	Most forward c.g. and most aft c.g.	As required	Low	0 to $V_{max}(TO)$	TO,CT
3.2.10.2	Control displacements -- maneuvering	↓	n(-) to n(+)	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	*,RT,CR,PA, L,CT
3.2.10.3	Control displacements -- gust regulation	--	$n_o(-)$ to $n_o(+)$	$h_{o_{min}}$ and $h_{o_{max}}$	↓	--
SECTION 3.3	HANDLING QUALITY REQUIREMENTS FOR VERTICAL FLIGHT PATH AXIS					
3.3.1.2.1	Response to attitude change -- steady-state response	--	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	$V_{o_{min}}$ and $V_{o_{min}}$ - 5 kt	PA
SECTION 3.4	HANDLING QUALITY REQUIREMENTS FOR LONGITUDINAL AXIS					
3.4.1	Response to Attitude Changes	Most aft c.g.	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	CO,RR,FF,CR LO,RT,All Category C
3.4.1.1	Relaxation in transonic flight	↓	↓	↓	Transonic	CO
SECTION 3.5	HANDLING QUALITY REQUIREMENTS FOR ROLL AXIS					
3.5.1	Roll Response to Roll Controller	--	1.0 and $n_o(+)$	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	*,CL,CR,LO, RT,DE,PA,L

† Combined with heaviest weight.

§ Combined with lightest weight.

* All applicable Category A Flight Phases.

-- No general guidance can be provided.

"As required" -- flight conditions are specified in requirement or are determined by nature of test maneuver.

TABLE 1 (3.1.10.2). (Continued)

REQUIREMENT NUMBER	TITLE	CRITICAL LOADING	LOAD FACTOR	ALTITUDE	SPEED	FLIGHT PHASE
3.5.2	Pilot-Induced Oscillations	↓	Minimum permissible to maximum permissible	MSL to h_{max}	V_{min} to V_{max}	--
3.5.4	Linearity of Roll Response to Roll Controller	Greatest rolling moment of inertia	As required (not above $0.8n_L$)	$h_{o_{min}}$, medium, $h_{o_{max}}$	↓	CO,GA,TF,CL,CR,TO,CT
3.5.6	Roll Response to Yaw Controller	Lightest weight	1.0	↓	↓	CO,CR,PA,L
3.5.7	Roll Control for Takeoff and Landing in Crosswinds	--	↓	Low	As required	Taxi,TO,L
3.5.8.1	Response to asymmetric thrust	Lightest weight	1.0	All	V_{min} to V_{max}	CO,GA,TF,CL,CR,TO,CT
3.5.8.2	Response to failures	--	All	$h_{o_{min}}$ and $h_{o_{max}}$	↓	--
3.5.8.3	Response to configuration or control mode change	--	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	--
3.5.8.4	Response to stores release	↓	$n_o(-)$ to $n_o(+)$	↓	$V_{o_{min}}$ to $V_{o_{max}}$	CO,GA,WD,AD
3.5.8.5	Response to armament delivery	↓	↓	↓	↓	*,RT
3.5.9.1	Control power - response to roll control inputs	Greatest and smallest rolling moments of inertia	As required (not above $0.8\ n_L$)	$h_{o_{min}}$, medium, $h_{o_{max}}$	↓	As required
3.5.9.2	Control power - steady sideslips	Lightest weight	1.0	↓	↓	CO,CR,PA,L
3.5.9.3	Control power - crosswinds	--	As required	Low	As required	TO,L,PA
3.5.9.4	Control power - engine failures	Lightest weight	1.0	$h_{o_{min}}$	Down to $V_{min}(TO)$	TO,CT
3.5.9.5	Control power - dives and pullouts	--	As required	2000 ft MSL to h_{max}	V_{MAT} to V_{max}	D,EO
3.5.9.6	Control power - stores release	--	$n_o(-)$ to $n_o(+)$	$h_{o_{min}}$, medium, $h_{o_{max}}$	$V_{o_{min}}$ to $V_{o_{max}}$	CO,GA,WD,AD
3.5.9.7	Control power - two engines inoperative	Lightest weight	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{range} (1 and 2 engines out)	--
3.5.9.8	Control power for other conditions	--	All	↓	All	--
3.5.10.1	Wheel control displacements	Greatest rolling moment of inertia	As required (not above $0.8n_L$)	↓	V_{min} to V_{max}	CO,GA,AR,TF,CR,GA,L
3.5.10.2	Forces to achieve required roll rates	Greatest and smallest rolling moments of inertia	↓	↓	↓	↓
3.5.10.3	Sensitivity	Smallest rolling moment of inertia	↓	↓	↓	↓
3.5.10.4	Breakout and centering forces	--	$n_o(-)$ to $n_o(+)$	$h_{o_{min}}$ and $h_{o_{max}}$	V_{min} to V_{max}	--

† Combined with heaviest weight.

§ Combined with lightest weight.

* All applicable Category A Flight Phases.

-- No general guidance can be provided.

"As required" -- flight conditions are specified in requirement or are determined by nature of test maneuver.

TABLE 1 (3.1.10.2). (Continued)

REQUIREMENT NUMBER	TITLE	CRITICAL LOADING	LOAD FACTOR	ALTITUDE	SPEED	FLIGHT PHASE
3.5.10.5	Free play	--	$n_o(-)$ to $n_o(+)$	$h_{o_{min}}$ and $h_{o_{max}}$	V_{min} to V_{max}	--
3.5.10.6.1	Force limits - steady turns	↓	As required	$h_{o_{min}}$, medium, $h_{o_{max}}$	$V_{o_{min}}$	CO,CR,LO,PA
3.5.10.6.2	Force limits - dives and pullouts	↓	↓	2000 ft MSL to h_{max}	V_{MAT} to V_{max}	D,ED
3.5.10.6.3	Force limits - cross-winds	↓	1.0	Low	As required	TO,L
3.5.10.6.4	Force limits - steady sideslips	↓	↓	↓	V_{min} to V_{max}	↓
3.5.10.6.5	Force limits - engine failures after takeoff	Lightest weight	↓	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min}(TO) to 1.4V_{min}	CR,TO,CT
<u>SECTION 3.6</u>	HANDLING QUALITY REQUIREMENTS FOR YAW AXIS					
3.6.1.1.1	Equivalent systems requirement - transient response	Greatest rolling moment of inertia	1.0 and $n_o(+)$	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	*,CR,RT,PA,L
3.6.1.1.2	Equivalent systems requirement - steady-state response	Lightest weight	1.0	↓	↓	CO,CR,PA,L
3.6.2.1	Yaw response to roll controller - coordination in turn entry and exit	Greatest yawing and rolling moments of inertia	↓	↓	↓	*,CR,PA,L
3.6.2.2	Pilot-induced oscillations	--	Minimum permissible to maximum permissible	MSL to h_{max}	↓	--
3.6.3	Yaw Control for Takeoff and Landing in Cross-winds	--	1.0	Low	As required	TO,L,Taxi
3.6.4.1	Response to asymmetric thrust	Lightest weight	1.0	$h_{o_{min}}$	0 to V_{max}(TO)	TO,CT
		↓	↓	All	V_{min} to V_{max}	CO,GA,TF,CR CL,TO,CT
		↓	↓	$h_{o_{min}}$, medium, $h_{o_{max}}$	1.4V_{min}	CR
3.6.4.2	Response to failures	--	All	↓	V_{min} to V_{max}	--
3.6.4.3	Response to configuration or control mode change	--	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	--
3.6.4.4	Response to stores release	↓	$n_o(-)$ to $n_o(+)$	↓	$V_{o_{min}}$ to $V_{o_{max}}$	CO,GA,WD,AD
3.6.4.5	Response to armament delivery	--	↓	↓	↓	*,RT
3.6.5.1	Control power - takeoff, landing, and taxi	--	As required	Low	0 to V_{max}(TO)	PA,TO,L,Taxi
3.6.5.2	Control power - two engines inoperative	Lightest weight	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{range} (1 and 2 engines out)	--

* All applicable Category A Flight Phases. -- No general guidance can be provided.

"As required" -- flight conditions are specified in requirement or are determined by nature of test maneuver.

TABLE 1 (3.1.10.2). (Concluded)

REQUIREMENT NUMBER	TITLE	CRITICAL LOADING	LOAD FACTOR	ALTITUDE	SPEED	FLIGHT PHASE
3.6.5.3	Control power - asymmetric loading	--	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	CO,GA,CR,D, PA,L
3.6.6	Yaw Axis Control Forces	↓	$n_o(-)$ to $n_o(+)$	↓	↓	*,CR,PA,L
3.6.6.1	Force linearity	Lightest weight	1.0	↓	↓	CO,CR,PA,L
3.6.6.2.1	Force limits - rolling maneuvers	Greatest rolling moment of inertia	As required	↓	↓	CO,GA,AR,TF, CR,PA,L
3.6.6.2.2	Force limits - steady turns	--	↓	↓	$V_{o_{min}}$	CO,CR,LO,PA
3.6.6.2.3	Force limits - speed changes	↓	1.0	↓	V_{min} to V_{max}	CO,GA,CR,D, PA,L
3.6.6.2.4	Force limits - crosswinds	--	1.0	Low	As required	TO,L
3.6.6.2.5	Force limits - asymmetric loading	↓	↓	$h_{o_{min}}$, medium, $h_{o_{max}}$	$V_{o_{min}}$ to $V_{o_{max}}$	--
3.6.6.2.6	Force limits - dives and pullouts	↓	As required	2000 ft MSL to h_{max}	V_{MAT} to V_{max}	D,ED
3.6.6.2.7	Force limits - go-arounds	Lightest weight	1.0	Low	V_{min}(PA) or landing speed	WO
3.6.6.2.8	Force limits-asymmetric thrust	↓	↓	$h_{o_{min}}$	0 to V_{max}(TO)	TO,CT
3.6.6.2.9	Force limits - failures	--	All	$h_{o_{min}}$ and $h_{o_{max}}$	V_{min} to V_{max}	--
3.6.6.2.10	Force limits - configuration or control mode changes	↓	1.0	$h_{o_{min}}$, medium, $h_{o_{max}}$	↓	↓
SECTION 3.8	HANDLING QUALITY REQUIREMENTS FOR COMBINED AXES					
3.8.1	Cross-Axis Coupling in Roll Maneuvers	--	0 to $0.8n_L$	$h_{o_{min}}$, medium, $h_{o_{max}}$	V_{min} to V_{max}	CO,GA,AR,TF
3.8.2	Crosstalk Between Pitch and Roll Controllers	↓	$n_o(-)$ to $n_o(+)$	↓	↓	--
3.8.3	Control Harmony	See MIL-S-83691 or MIL-D-8708, whichever is applicable for flight demonstration. More severe conditions generally will be investigated by analysis and model testing.				
3.8.4	Flight at High Angle of Attack	↓	↓	↓	↓	↓

* All applicable Category A Flight Phases. -- No general guidance can be provided.

"As required" flight conditions are specified in requirement or are determined by nature of test maneuver.

3.2.1.2 Pitch axis bandwidth requirements. The bandwidth of the open-loop pitch attitude response to pitch controller shall have the following characteristics: ____________________.

3.2.2 Pilot-Induced Pitch Oscillations

3.2.2.1 Pilot-induced pitch oscillations due to phase lag. The total phase angle by which normal acceleration measured at the pilot's location lags the pilot's pitch control force input at a criterion frequency, ω_R, must be less than ______________.

3.2.2.2 Pilot-induced pitch oscillations — qualitative requirement. There shall be no tendency for pilot-induced oscillations, that is, sustained or uncontrollable oscillations resulting from the efforts of the pilot to control the aircraft. The pitch attitude response dynamics of the airframe plus control system shall not change abruptly with the motion amplitudes of pitch, pitch rate or normal acceleration unless it can be shown that this will not result in a pilot-induced oscillation.

3.2.3 Residual Pitch Oscillations. Any sustained residual oscillations in calm air shall not interfere with the pilot's ability to perform the tasks required in service use of the aircraft. For Levels 1 and 2, oscillations in normal acceleration at the pilot's station greater than ± 0.02 g will be considered excessive for any Flight Phase. These requirements shall apply with the pitch control fixed and with it free.

3.2.4 Vertical Acceleration at Pilot Station. Vertical acceleration at the pilot station due to pitch control inputs shall have the following characteristics: __________________.

3.2.5 Pitch Axis Response to Secondary Controllers. The pitch attitude response to a rapid change in secondary cockpit flight control (throttle, DLC, etc.) shall not exceed the following: ________________.

3.2.6 [Reserved]

3.2.7 Pitch Axis Response to Other Inputs

3.2.7.1 Pitch axis response to auxiliary controls. The maximum allowable pitch response to any auxiliary control shall not exceed ________________.

3.2.7.2 Pitch axis response to failures

a) Closed-Loop: The pitch attitude motions following sudden aircraft system or component failures shall be such that dangerous conditions can be avoided by pilot corrective

action. A time delay of at least ____ sec between the failure and initiation of pilot corrective action shall be incorporated when determining compliance. No single failure of any component or system shall result in Level 3 pitch-axis flying qualities; Special Failure States (1.6.3) are excepted. The crew member concerned shall be provided with immediate and easily interpreted indications whenever failures occur that require or limit any flight crew action or decision.

b) Open-Loop: With controls free, the aircraft motions due to partial or complete failure of the augmentation system shall not exceed the following limits: ____________, for at least ___ seconds following the failure.

3.2.7.3 Pitch axis response to configuration or control mode change. The transient motions and trim changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall be such that dangerous flying qualities never result. With controls free, the motion transients resulting from these situations shall not exceed the following limits for at least ____ seconds following the transfer: ________________. These requirements apply only for Aircraft Normal States (1.6.1).

3.2.7.4 Pitch axis response to stores release. The intentional release of any stores shall not result in objectionable flight characteristics for Levels 1 and 2. However, the intentional release of stores shall never result in dangerous or intolerable flight characteristics. This requirement applies for all flight conditions and store loadings at which normal or emergency store release is structurally permissible.

3.2.7.5 Pitch axis response to armament delivery. Operation of movable parts such as bomb bay doors, cargo doors, armament pods, refueling devices, and rescue equipment, or firing of weapons, release of bombs, or delivery or pickup of cargo shall not cause buffet, trim changes, or other characteristics which impair the tactical effectiveness of the aircraft under any pertinent flight conditions. These requirements shall be met for Levels 1 and 2.

3.2.7.6 Buffet. Within the boundaries of the Operational Flight Envelope, there shall be no objectionable buffet which might detract from the effectiveness of the aircraft in executing its intended missions.

3.2.8 Pitch Axis Control Power

3.2.8.1 Pitch axis control power in unaccelerated flight. In steady 1 g flight at all service altitudes, the attainment of all speeds between V_S and V_{max} shall not be limited by the effectiveness of the longitudinal control or controls.

3.2.8.2 Pitch axis control power in maneuvering flight. Within the Operational Flight Envelope, it shall be possible to develop, by use of the pitch control alone, the following range of load factors: ______________. This maneuvering capability is required at constant altitude at the 1 g trim speed and, with trim and throttle settings not changed by the crew, over a range about the trim speed the lesser of ±15 percent or ±50 kt equivalent airspeed (except where limited by the boundaries of the Operational Flight Envelope).

3.2.8.3 Pitch axis control power in takeoff. The effectiveness of the pitch control shall not restrict the takeoff performance of the aircraft. Satisfactory takeoffs shall not be dependent upon use of the trim controller during takeoff or on complicated control manipulation by the pilot. It shall be possible to obtain and maintain the following attitudes ______________ during the takeoff roll.

3.2.8.4 Pitch axis control power in landing. The pitch control shall be sufficiently effective in the landing Flight Phase in close proximity to the ground so that ______________.

3.2.8.5 Pitch axis control power for other conditions. Control authority, rate and hinge moment capability shall be sufficient to assure safety throughout the combined range of all attainable angles of attack (both positive and negative) and sideslip. This requirement applies to the prevention of loss of control and to recovery from any situation for all maneuvering, including pertinent effects of factors such as regions of control-surface-fixed instability, inertial coupling, fuel slosh, the influence of symmetric and asymmetric stores, stall/post-stall/spin characteristics, atmospheric disturbances and Aircraft Failure States (maneuvering flight appropriate to the Failure State is to be included). Consideration shall be taken of the degrees of effectiveness and certainty of operation of limiters, c.g. control malfunction or mismanagement, and transients from failures in the propulsion, flight control and other relevant systems.

3.2.9 Pitch Axis Control Forces

3.2.9.1 Pitch axis control forces -- steady-state control force per g.

a) Control Feel and Stability in Maneuvering Flight at Constant Speed. In steady turning flight and in pullups and pushovers at constant speed, for Levels 1 and 2 there shall be no tendency for the aircraft pitch attitude or angle of attack to diverge aperiodically with controls fixed or with controls free. For the above conditions, the incremental control force required to maintain a change in normal load factor and pitch rate shall be in

the same sense (aft - more positive, forward - more negative) as those required to initiate the change. These requirements apply for all local gradients throughout the range of service load factors defined in 1.5.2.

b) Control Forces in Maneuvering Flight. At constant speed in steady turning flight, pullups and pushovers, the variations in pitch controller force with steady-state normal acceleration shall have no objectionable nonlinearities within the following load factor ranges:

CLASS	MIN.	MAX.
I, II & III		
IV		

Outside this range, a departure from linearity resulting in a local gradient which differs from the average gradient for the maneuver by more than 50 percent is considered excessive, except that larger increases in force gradient are permissible at load factors greater than 0.85 n_L. The local force gradients shall be: ______________. In addition, F_s/n should be near the Level 1 upper boundaries of these gradients for combinations of high frequency and low damping. The term gradient does not include that portion of the force versus n curve within the breakout force.

For side stick controllers, the contractor shall show that the control force gradients will produce suitable flying qualities.

3.2.9.2 Pitch axis control forces — transient control force per g. The buildup of control force during the maneuver entry must not lag the buildup of normal acceleration at the pilot's location. In addition, the frequency response of normal acceleration at the pilot station to pitch control force input shall have the following characteristics: ______________.

3.2.9.3 Pitch axis control forces -- control force variations during rapid speed changes. When the aircraft is accelerated and decelerated rapidly through the operational speed range and through the transonic speed range by the most critical combination of changes in power, actuation of deceleration devices, steep turns and pullups, the magnitude and rate of the associated trim change shall not be so great as to cause difficulty in maintaining the desired load factor by normal pilot techniques.

3.2.9.4 Pitch axis control forces — control force vs. control deflection

3.2.9.4.1 Steady-state control force/deflection gradient. The average gradient of pitch-control force per unit of pitch-control deflection at constant speed shall be within the following range: ____________________.

3.2.9.4.2 Transient control force vs. deflection The deflection of the pilot's control must not lead the control force throughout the frequency range of pilot control inputs. In addition, the peak pitch control forces developed during abrupt maneuvers shall not be objectionably light.

3.2.9.5 Pitch axis control forces — control centering and breakout forces. Longitudinal controls should exhibit positive centering in flight at any normal trim setting. Although absolute centering is not required, the combined effects of centering, breakout force, stability and force gradient shall not produce objectionable flight characteristics, such as poor precision-tracking ability, or permit large departures from trim conditions with controls free. Breakout forces, including friction, preload, etc., shall be within the following limits: ____________________. These values refer to the cockpit control force required to start movement of the control surface.

3.2.9.6 Pitch axis control forces — free play. The free play (and possible associated hysteresis) in the longitudinal controller shall not result in objectionable flight characteristics, especially for small amplitude inputs. Hysteresis and free play should be within the following boundaries: ________________.

3.2.9.7 Pitch axis control force limits

3.2.9.7.1 Pitch axis control force limits — takeoff. With the trim setting optional but fixed, the pitch-control forces required during all types of takeoffs for which the aircraft is designed, including short-field takeoffs and assisted takeoffs such as catapult or rocket-augmented, shall be within the following limits: ______________.

3.2.9.7.2 Pitch axis control force limits -- landing. The pitch control forces for landing shall be less than ________________ for the recommended approach speed and fixed trim settings. This applies in both presence and absence of ground effect.

3.2.9.7.3 Pitch axis control force limits -- dives

Service Flight Envelope. With the aircraft trimmed for level flight at speeds throughout the Service Flight Envelope, the control forces in dives to all attainable speeds within the Service Flight Envelope shall

not exceed _______. In similar dives, but with use of trim following the dive entry, it shall be possible with normal piloting techniques to maintain the forces within the following limits: _______.

Permissible Flight Envelope. With the aircraft trimmed for level flight at V_{MAT} but with use of trim optional in the dive, it shall be possible to maintain the pitch control force within the following limits in dives to all attainable speeds within the Permissible Flight Envelope: _______. The force required for recovery from these dives shall not exceed: _______. Trim and deceleration devices, etc., may be used to assist in recovery if no unusual pilot technique is required.

3.2.9.7.4 Pitch axis control force limits — sideslips. With the aircraft trimmed for straight, level flight with zero sideslip, the pitch-control force required to maintain constant speed in steady sideslips with up to _____ pounds of pedal force in either direction, or in sideslips as specified in the Operational Flight Envelope, shall not exceed the pitch-control force that would result in a 1 g change in normal acceleration. In no case, however, shall the pitch-control force exceed: _______________. If a variation of pitch-control force with sideslip does exist, it is preferred that increasing pull force accompany increasing sideslip, and that the magnitude and direction of the force change be similar for right and left sideslips. For Level 3 there shall be no uncontrollable pitching motions associated with the sideslips discussed above.

3.2.9.7.5 [Reserved]

3.2.9.7.6 Pitch axis control force limits — failures. The change in longitudinal control force required to maintain trim pitch attitude following complete or partial failure of the augmentation system shall not exceed the following limits: _________________.

3.2.9.7.7 Pitch axis control force limits -- configuration or control mode change. The control force changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall not exceed the following limits: _________________.

3.2.9.8 Pitch axis trim systems. In straight flight, throughout the Operational Flight Envelope the trimming system shall be capable of reducing the steady-state control forces to _________________. The failures to be considered in applying Level 2 and 3 requirements shall include trim sticking and runaway in either direction. It is permissible to meet Level 2 and 3 requirements by providing the pilot with alternate trim mechanisms or override capability.

3.2.9.8.1 Pitch axis trim systems -- rate of operation. Trim devices shall operate rapidly enough to enable the pilot to maintain low control forces under changing conditions normally encountered in service, yet not so rapidly as to cause oversensitivity or trim precision difficulties under any conditions.

3.2.9.8.2 Pitch axis trim systems — stalling of trim systems. Stalling of a trim system due to aerodynamic loads during maneuvers shall not result in an unsafe condition. Specifically, the longitudinal trim system shall be capable of operating during the dive recoveries of 3.2.9.7.3 at any attainable permissible n, at any possible position of the trimming device.

3.2.9.8.3 Pitch axis trim systems — irreversibility. All trimming devices shall maintain a given setting indefinitely unless changed by the pilot, or by a special automatic interconnect (such as to the landing flaps), or by the operation of an augmentation device. If an automatic interconnect or augmentation device is used in conjunction with a trim device, provision shall be made to ensure the accurate return of the device to its initial trim position on removal of each interconnect or augmentation command.

3.2.10 Pitch Axis Control Displacements

3.2.10.1 Pitch axis control displacements — takeoff. With the trim setting optional but fixed, the pitch-control travel during all types of takeoffs for which the aircraft is designed shall not exceed ____ percent of the total travel, stop-to-stop. Here the term takeoff includes ground run, rotation and liftoff, the ensuing acceleration to V_{max} (TO), and the transient caused by assist cessation. Takeoff power shall be maintained until V_{max} (TO) is reached, with the landing gear and high-lift devices retracted in the normal manner at speeds from $V_{o_{min}}$ (TO) to V_{max} (TO).

3.2.10.2 Pitch axis control displacements — maneuvering. For all types of pitch controllers, the control motions in maneuvering flight shall not be so large or so small as to be objectionable. In steady turning flight and in pullups at constant speed, the incremental control deflection required to maintain a change in normal load factor and pitch rate shall be in the same sense (aft — more positive, forward — more negative) as those required to initiate the change.

3.2.10.3 Pitch axis control displacements — gust regulation. The ability of the aircraft to perform operational maneuvers required of it shall not be limited in the ____________ atmospheric disturbances defined in 3.9 by control displacement or control surface deflection rates. For powered or boosted controls, the effect of engine speed and the duty cycle of both primary and secondary control together with the pilot control techniques shall be included when establishing compliance with this requirement.

3.3 HANDLING QUALITY REQUIREMENTS FOR VERTICAL FLIGHT PATH AXIS

3.3.1 Vertical Axis Response to Attitude Change

3.3.1.1 Vertical axis response to attitude change — transient response

a) The short-term flight path response to attitude changes shall have the following characteristics: ____________________.

b) If a designated controller other than attitude is the primary means of controlling flight path, the flight path response to an attitude change can be degraded to the following: ________________.

c) In all cases the pitch attitude response must lead the flight path angle by ________________ and must have a magnitude equal to or greater than the flight path angle.

3.3.1.2 Vertical axis response to attitude change — steady-state response. For aircraft without a designated secondary flight path control the steady-state path response to attitude inputs shall be as follows: ___________.

3.3.1.2.1 Relaxation for aircraft with designated flight path controller. For aircraft with a designated secondary flight path control the required flight path response to attitude changes is ___________.

3.3.2 Vertical Axis Response to Designated Flight Path Controller

3.3.2.1 Vertical axis response to designated flight path controller — transient response. When used as a primary controller the short-term flight path response to designated flight path controller inputs shall have the following characteristics: __________.

3.3.2.2 Vertical axis response to designated flight path controller — steady-state response. At all flight conditions the flight path controller will produce flight path motions in the same direction as the applied control and which are of the same sign as the steady-state values.

3.3.3 Vertical Axis Response to Other Inputs

3.3.3.1 Vertical axis response to auxiliary controls, stores release, and armament. There shall be no objectionable transients in flight path response due to the use of other auxiliary controls, or stores or armament release.

3.3.3.2 Vertical axis response to failures. No single failure of any component or system shall result in objectionable flying qualities.

3.3.4 Flight Path Control Power

3.3.4.1 Control power for designated primary flight path controller. If a separate control is provided for direct lift or flight path it shall be capable of producing the following changes in flight path ______________ following full actuation of the controller. This shall be accomplished with pitch attitude held fixed and the speed trimmed for ________.

3.3.4.2 Control power for designated secondary flight path controller. The secondary controller shall be sufficient to produce the following changes in flight path: ____________________.

3.3.5 Flight Path Controller Characteristics. The breakout, centering, and force gradient characteristics of the designated flight path controller shall be within the following limits:

Breakout:	± __________ lb
Centering:	± __________ %
Force gradient:	______________

3.4 HANDLING QUALITY REQUIREMENTS FOR LONGITUDINAL (SPEED) AXIS

3.4.1 Speed Response to Attitude Changes

a. The correlation between airspeed and pitch attitude shall be as follows: ___________________.

b. For Levels 1 and 2 there shall be no tendency for the airspeed to diverge aperiodically when the aircraft pitch attitude is disturbed from trim by any means. This requirement shall be considered satisfied if the gradient of pitch control force with airspeed is negative. Demonstration of positive phugoid damping in Paragraph 3.2.1 shall also be accepted as evidence of compliance.

c. For Level 3, the airspeed divergence characteristics must be within the following limits: ______.

3.4.1.1 Speed response to attitude changes — relaxation in transonic flight. The requirements of 3.4.1 may be relaxed in the transonic speed range as follows: ____________.

3.4.2 Speed Response to Speed Controller

3.4.2.1 Speed response to speed controller — transient response. The short-term airspeed response to the designated speed controller shall have the following characteristics: ________________.

3.4.2.2 Speed response to speed controller — steady-state response. The steady-state airspeed response to a step change of the designated speed controller shall have the following characteristics: ________________.

3.4.3 Speed Axis Response to Other Inputs. There shall be no airspeed responses due to use of other controls, stores or armament release, configuration changes, or failures of any system or subsystem that result in objectionable flying qualities.

3.4.4 Speed Axis Control Power. The speed controller shall be capable of providing the following range of speeds throughout the Operational Flight Envelope: ________________.

3.4.5 Speed Axis Controller Characteristics.

a) Breakout forces shall not exceed ____________.

b) Friction shall be adjustable from ___ lb to ___ lb.

c) Displacements shall be sufficient to provide from idle to full thrust and shall not be so large or so small as to be objectionable. The average control gradient shall not be less than __________.

3.5 HANDLING QUALITY REQUIREMENTS FOR ROLL AXIS

3.5.1 Roll Response to Roll Controller

3.5.1.1 Roll axis lower-order equivalent system requirements

3.5.1.1.1 Roll mode. The equivalent roll mode time constant, T_R, shall be no greater than the following: ________________

3.5.1.1.2 Spiral stability. The combined effects of spiral stability, flight-control-system characteristics and rolling moment change with speed shall be such that the bank angle response shall have the following characteristics: ____________ following a disturbance in bank of up to 20 degrees. This requirement shall be met with the airplane trimmed for wings-level, zero-yaw-rate flight with the cockpit controls free.

3.5.1.1.3 Coupled roll-spiral oscillation. A coupled roll-spiral mode will be permitted provided it has the following characteristics: ____________________.

3.5.1.1.4 Roll rate oscillations. The value of the parameter p_{osc}/p_{av} following a yaw-control-free step roll command shall be within the following limits: ____________. This requirement applies for step roll commands up to the magnitude that causes a 60 degree bank angle change in $1.7T_d$ seconds.

Configurations that meet the appropriate Category A dutch roll damping requirement (Paragraph 3.6.1.1) should be considered to meet this requirement as long as ω_ϕ/ω_d is within the following limits: __________.

3.5.1.1.5 Time delay. The value of the equivalent time delay, τ_{e_p}, shall be no greater than the following: ________________.

3.5.2 Pilot-Induced Roll Oscillations. There shall be no tendency for sustained or uncontrollable roll oscillations resulting from efforts of the pilot to control the airplane.

3.5.3 Residual Roll Oscillations. Any sustained residual oscillations in calm air shall not interfere with the pilot's ability to perform the tasks required in service use of the airplane.

3.5.4 Linearity of Roll Response to Roll Controller. There shall be no objectionable nonlinearities in the variation of rolling response with roll control deflection or force. Sensitivity or sluggishness in response to small control deflections or force shall be avoided.

3.5.5 Lateral Acceleration at Pilot Station. The ratio of maximum lateral acceleration at the pilot station to maximum roll rate shall not exceed __________ for the first 2-1/2 seconds following a step roll control input.

3.5.6 Roll response to yaw controller. The following requirements are expressed in terms of characteristics in yaw-control-induced steady, zero-yaw-rate sideslips with the airplane trimmed for wings-level straight flight, at sideslip angles up to those produced or limited by:

a) Full yaw-control-pedal deflection, or

b) 250 pounds of yaw-control-pedal force, or

c) Maximum roll control or surface deflection,

except that for single-propeller-driven airplanes during waveoff (go-around), yaw-control-pedal deflection in the direction opposite to that required for wings-level straight flight need not be considered beyond the deflection for a 10 degree change in sideslip from the wings-level straight flight condition. At these sideslip angles the following shall apply:

a) A decrease in right bank angle shall not accompany an increase in right sideslip, and a decrease in left bank angle shall not accompany an increase in left sideslip. Zero roll control force or deflection is acceptable, whereas

b) A right roll-control deflection and/or force shall not accompany left sideslips, and a left roll-control deflection and/or force shall not accompany right sideslips. For Levels 1 and 2, the variation of roll-control deflection and force with sideslip angle shall be essentially linear. This requirement may, if necessary, be excepted for waveoff (go-around) if task performance is not impaired and no more than 50 percent of roll-control power available to the pilot, and no more than 10 pounds of roll-control force are required in a direction opposite to that specified herein. In addition, for Levels 1 and 2 positive effective dihedral (right roll control for right sideslip and left roll control for left sideslip) shall never be so great that more than 75 percent of roll-control power available to the pilot, and no more than 10 pounds of roll-stick force or 20 pounds of roll-wheel force, are required for sideslip angles that might be experienced in service employment.

3.5.7 <u>Roll axis control for takeoff and landing in crosswinds</u>. It shall be possible to take off and land with normal pilot skill and technique in 90 deg crosswinds from either side of velocities up to ____ kt.

3.5.8 <u>Roll Axis Response to Other Inputs</u>

3.5.8.1 <u>Roll axis response to asymmetric thrust</u>. The airplane motions following sudden asymmetric loss of thrust shall be such that dangerous conditions can be avoided by pilot corrective action. A realistic time delay of at least ___ second shall be considered.

3.5.8.2 <u>Roll axis response to failures</u>.

a) Closed-Loop: The aircraft motions following sudden aircraft system or component failures shall be such that dangerous conditions can be avoided by pilot corrective action. A time delay of at least ____ sec between the failure and initiation of pilot corrective action shall be incorporated when determining compliance. No single failure of any component or system shall result in Level 3 flying qualities; Special Failures States (1.6.3) are excepted. The crew member concerned shall be provided with immediate and easily interpreted indications whenever failures occur that require or limit any flight crew action or decision.

b) Open-Loop: With controls free, the aircraft motions due to partial or complete failure of the augmentation system shall not exceed the following limits: ________________, for at least ___ seconds following the failure.

3.5.8.3 Roll axis response to configuration or control mode change. The transient motions and trim changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall be such that dangerous flying qualities never result. With controls free, the motion transients resulting from these situations shall not exceed the following limits for at least ____ seconds following the transfer: ________________. These requirements apply only for Aircraft Normal States.

3.5.8.4 Roll axis response to stores release. The intentional release of any stores shall not result in objectionable flight characteristics for Levels 1 and 2. However, the intentional release of stores shall never result in dangerous or intolerable flight characteristics. This requirement applies for all flight conditions and store loadings at which normal or emergency store release is structurally permissible.

3.5.8.5 Roll axis response to armament delivery. Operation of moveable parts such as bomb bay doors, cargo doors, armament pods, refueling devices, and rescue equipment, or firing of weapons, release of bombs, or delivery or pickup of cargo shall not cause buffet, trim changes, or other characteristics which impair the tactical effectiveness of the airplane under any pertinent flight conditions. These requirements shall be met for Levels 1 and 2.

3.5.9 Roll Axis Control Power

3.5.9.1 Roll axis control power — response to roll control inputs. The response to full roll control input shall have the following characteristics: ____________________.

3.5.9.2 Roll axis control power in steady sideslips. For Levels 1 and 2, positive effective dihedral (right roll control for right sideslip and left roll control for left sideslip) shall never be so great that more than ___ percent of roll control power available to the pilot is required for sideslips which might be encountered in service deployment.

3.5.9.3 Roll axis control power in crosswinds.

a) It shall be possible to taxi at any angle to a ___ kt wind.

b) Roll control power, in conjunction with other normal means of control, shall be adequate to maintain a straight path during the takeoff run, or landing rollout, in crosswinds up to those specified in 3.5.7.

c) Roll control power shall be adequate to maintain wings level with up to ____ deg of sideslip in the power approach. For Level 1 this shall require not more than ____ percent of the control power available to the pilot.

d) Following sudden asymmetric loss of thrust from any factor, the airplane shall be safely controllable in roll in the crosswinds of 3.5.7 from the unfavorable direction.

3.5.9.4 Roll axis control power for engine failure. During the takeoff run it shall be possible to maintain roll control of the aircraft, following a sudden loss of thrust from the most critical propulsive source. This requirement shall apply from a minimum speed of V_{min}(TO) to a maximum speed of V_{max}(TO).

The roll control required shall not exceed ___ percent of the available roll control power. This assumes takeoff thrust is maintained on the operative engines with trim at normal setting for symmetric thrust. The aircraft may be banked up to 5 deg away from the inoperative engine.

3.5.9.5 Roll axis control power in dives and pullouts. Roll control power shall be adequate to maintain wings level without retrimming, throughout the dives and pullouts of 3.2.9.7.3.

3.5.9.6 Roll axis control power for stores release. Roll control power shall be adequate to regain wings level, without retrimming, following intentional release of any stores, to the maximum load factors specified in 3.2.8.2 with adequate control margin.

3.5.9.7 Roll axis control power for two engines inoperative. At the one-engine-out speed for maximum range with any engine initially failed, upon failure of the most critical remaining engine the roll control power shall be adequate to stop the transient motion and thereafter to maintain straight flight from that speed to the speed for maximum range with both engines failed. In addition, it shall be possible to effect a safe recovery at any service speed above $V_{o_{min}}$ (CL) following sudden simultaneous failure of the two critical engines.

3.5.9.8 Roll axis control power for other conditions. Control authority, rate and hinge moment capability shall be sufficient to assure safety throughout the combined range of all attainable angles of attack (both positive and negative) and sideslip. This requirement applies to the prevention of loss of control and to recovery from any situation for all maneuvering, including pertinent effects of factors such as regions of control-surface-fixed instability, inertial coupling, fuel slosh, the influence of symmetric and asymmetric stores, stall/post-stall/spin characteristics, atmospheric disturbances and Aircraft Failure States (maneuvering flight appropriate to the Failure State is to be included). Consideration shall be taken of the degrees of effectiveness and certainty of operation of limiters, c.g. control malfunction or mismanagement, and transients from failures in the propulsion, flight control and other relevant systems.

3.5.10 Roll Axis Control Forces and Displacements

3.5.10.1 Wheel control displacements. For airplanes with wheel controllers, the wheel throw necessary to meet the roll performance requirements specified in 3.5.9 shall not exceed ____ degrees in either direction.

3.5.10.2 Roll axis control forces to achieve required roll rates. The roll control force required to obtain the rolling performance specified in 3.5.9.1 shall be neither greater than ______________ nor less than __________.

3.5.10.3 Roll axis control sensitivity. The roll control force gradient for stick-controlled Class IV airplanes shall have the following characteristics: ________________. In case of conflict between the requirements of 3.5.10.3 and 3.5.10.2, the requirements of 3.5.10.3 shall govern.

3.5.10.4 Roll axis control forces — control centering and breakout forces. Lateral controls should exhibit positive centering in flight at any normal trim conditions.

The combined effects of centering, breakout force, damping, and force gradient shall not produce objectionable flight characteristics.

Breakout forces, including friction, preload, etc., shall be within the following limits: ____________________.

3.5.10.5 Roll axis control forces — free play. The free play in the lateral controller shall not result in objectionable flight characteristics, especially for small amplitude inputs. Free play should be within the following boundaries: ____________________.

3.5.10.6 Roll axis control force limits

3.5.10.6.1 Roll axis control force limits — steady turns. It shall be possible to maintain steady turns with the airplane trimmed for wings-level straight flight in either direction with the yaw controls free at the following combinations of bank angle and roll controller force characteristics: ________________________.

3.5.10.6.2 Roll axis control force limits — dives and pullouts. Roll control forces shall not exceed ___ lb in dives and pullouts to the maximum speeds specified in the Service Flight Envelope.

3.5.10.6.3 Roll axis control force limits — crosswinds. It shall be possible to take off and land in the crosswinds specified in 3.5.9.3 without exceeding the following roll control forces: __________________.

3.5.10.6.4 Roll axis control force limits — steady sideslips. In final approach the roll control forces shall not exceed ___ lb when in a straight, steady sideslip of ___ deg.

3.5.10.6.5 Roll axis control force limits — engine failures after takeoff. Following a thrust loss from the most critical factor after takeoff the roll control forces shall not exceed ___ lb, with takeoff thrust maintained on the operative engines and trim at the normal settings for takeoff with symmetric thrust. Automatic devices that normally operate in the event of a thrust failure may be used, and the airplane may be banked up to 5 degrees away from the inoperative engine.

3.5.10.6.6 Roll axis control force limits — configuration or control mode change. The control force changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall not exceed the following limits: ______________.

3.6 HANDLING QUALITY REQUIREMENTS FOR YAW AXIS

3.6.1 Yaw Axis Response to Yaw Controller

3.6.1.1 Yaw axis lower-order equivalent system requirements

3.6.1.1.1 Dynamic response. The equivalent parameters describing the response of sideslip to a yaw control input shall have the following *characteristics:* ________________. The requirements shall be met in trimmed and in maneuvering flight with cockpit controls fixed and with them free, in oscillations of any magnitude that might be experienced in operational use. If the oscillation is nonlinear with amplitude, the requirement shall apply to each cycle of the oscillation. In calm air residual oscillations may be tolerated only if the amplitude is sufficiently small that the motions are not objectionable and do not impair mission performance.

3.6.1.1.2 Steady-state response. The long-term response to yaw-control-pedal deflections shall have the following characteristics: ________________.

This requirement applies to yaw-control-induced steady, zero-yaw-rate sideslips with the airplane trimmed for wings-level straight flight, at sideslip angles up to thos produced or limited by:

a) Full yaw-control-pedal deflection, or

b) 250 pounds of yaw-control-pedal force, or

c) Maximum roll control or surface deflection,

except that for single-propeller-driven airplanes during waveoff (go-around), yaw-control-pedal deflection in the direction opposite to that required for wings-level straight flight need not be considered beyond the deflection for a 10 deg change in sideslip from the wings-level straight flight condition.

Right yaw-control-pedal force shall produce left sideslips and left yaw-control-pedal force shall produce right sideslips. For Levels 1 and 2 the following requirements shall apply. The variation of sideslip angle with yaw-control-pedal force shall be essentially linear for sideslip angles between _____ degree and _____ degrees. For larger sideslip angles, an increase in yaw-control-pedal force shall always be required for an increase in sideslip.

3.6.1.2 Yaw axis bandwidth requirements

3.6.1.2.1 Bandwidth requirements for wings-level turn mode

a) Dynamic response to direct force control (DFC) input. The bandwidth of the open-loop response of heading or lateral flight path angle to the DFC control input shall be greater than ________ for Flight Phase ___. Turns shall occur at approximately zero sideslip angle and zero bank angle when using the DFC controller.

b) Steady-state response to direct force control input. Maximum DFC control inputs shall produce at least ___.

c) Direct force control forces and deflections. Use of the primary DFC control shall not require use of another control manipulator to meet the above dynamic response requirement. The controller characteristics shall meet the following requirements: _____________.

d) Pilot acceleration. Abrupt, large DFC inputs shall not produce pilot head or arm motions which interfere with task performance. Pilot restraints shall not obstruct his normal field of view nor interfere with manipulation of any cockpit control required for task performance.

3.6.2 Yaw Axis Response to Roll Controller

3.6.2.1 Coordination in turn entry and exit

3.6.2.1.1 Coordination in turn entry and exit — requirement 1. The sideslip excursions to step roll control inputs with yaw control free shall meet the following criterion: _________________.

3.6.2.1.2 Coordination in turn entry and exit — requirement 2. The yaw control characteristics required to maintain zero sideslip for roll control inputs shall meet the following criterion: __________.

3.6.2.2 Pilot-induced yaw oscillations. There shall be no tendency for sustained or uncontrollable yaw oscillations resulting from efforts of the pilot to control the aircraft.

3.6.2.3 Residual yaw oscillations. Any sustained residual oscillations in calm air shall not interfere with the pilot's ability to perform the tasks required in service use of the aircraft.

3.6.3 Yaw Axis Control for Takeoff and Landing in Crosswinds. It shall be possible to take off and land with normal pilot skill and technique in 90 deg crosswinds from either side of velocities up to __________.

3.6.4 Yaw Axis Response to Other Inputs

3.6.4.1 Yaw axis response to asymmetric thrust. It shall be possible for the pilot to maintain directional control of the aircraft following a loss of thrust from the most critical propulsive source.

a) Takeoff: During takeoff it shall be possible to maintain a straight path without deviations of more than ___ ft. For the continued takeoff, the requirement shall be met when thrust is lost at speeds from the refusal speed (based on the shortest runway from which the airplane is designed to operate) to the maximum takeoff speed, with takeoff thrust maintained on the operative engine(s), using only controls not dependent upon friction against the takeoff surface or upon release of the pitch, roll, yaw or throttle controls. For the aborted takeoff, the requirement shall be met at all speeds below the maximum takeoff speed; however, additional controls such as nose-wheel steering and differential braking may be used. Automatic devices that normally operate in the event of a thrust failure may be used in either case.

b) After takeoff: After takeoff it shall be possible without a change in selected configuration to achieve straight flight following sudden asymmetric loss of thrust from the most critical factor at speeds from V_{min} (TO) to V_{max} (TO), and thereafter to maintain straight flight throughout the climbout. Automatic devices that normally operate in the event of a thrust failure may be used, and the airplane may be banked up to 5 degrees away from the inoperative engine.

c) Takeoff and landing in crosswinds: The aircraft shall be safely controllable in the crosswinds of 3.6.3 from the unfavorable direction.

d) In-flight: The airplane motions following sudden asymmetric loss of thrust shall be such that dangerous conditions can be avoided by pilot corrective action. A realistic time delay of at least ____ second shall be incorporated. In addition, the static directional stability shall be such that at all speeds above ____, with asymmetric loss of thrust from the most critical factor while the other engine(s) develop normal rated thrust, the airplane with yaw control pedals free may be balanced directionally in steady straight flight. The trim settings shall be those required for wings-level straight flight prior to the failure.

3.6.4.2 Yaw axis response to failures. The yawing motions following sudden airplane system or component failures shall be such that dangerous conditions can be avoided by pilot corrective action. A realistic time delay between the failure and initiation of pilot corrective action shall be incorporated when determining compliance. No single failure of any component or system shall result in dangerous or intolerable flying qualities; Special Failure States (1.6.3) are excepted. The crew member concerned shall be provided with immediate and easily interpreted indications whenever failures occur that require or limit any flight crew action or decision. With controls free, the yawing motions due to failures shall not exceed ______________.

3.6.4.3 Yaw axis response to configuration or control mode change. The transient motions and trim changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall be such that dangerous flying qualities never result. With controls free, the transients resulting from these situations shall not exceed the following limits for at least ____ seconds following the transfer: ______________________. These requirements apply only for Aircraft Normal States, within the Service Flight Envelope.

3.6.4.4 Yaw axis response to stores release. The intentional release of any stores shall not result in objectionable flight characteristics for Levels 1 and 2. However, the intentional release of stores shall never result in dangerous or intolerable flight characteristics. This requirement applies for all flight conditions and store loadings at which normal or emergency store release is structurally permissible.

3.6.4.5 Yaw axis response to armament delivery. Operation of movable parts such as bomb bay doors, cargo doors, armament pods, refueling devices, and rescue equipment, or firing of weapons, release of bombs, or delivery or pickup of cargo shall not cause buffet, trim changes, or other characteristics which impair the tactical effectiveness of the aircraft under any pertinent flight conditions. These requirements shall be met for Levels 1 and 2.

3.6.5 Yaw Axis Control Power. Directional stability and control characteristics shall enable the pilot to balance yawing moments and control yaw and sideslip.

3.6.5.1 Yaw axis control power for takeoff, landing, and taxi.

a) It shall be possible to taxi on a dry surface at any angle to a ___ kt wind.

b) In taxi on wet, snow-packed, or icy runways, directional control shall be maintained by use of aerodynamic controls alone at all airspeeds above ____ kt. For very slippery runways, the requirement need not apply for crosswind components at which the force tending to blow the airplane off the runway exceeds the opposing tire-runway frictional force with the tires supporting all of the airplane's weight.

c) In the takeoff run, landing rollout, and taxi, yaw control power shall be adequate to maintain a straight path on the ground or other landing surface. This applies to calm air and in crosswinds up to the values specified in 3.6.3, on wet runways for all aircraft, and on snow-packed and icy runways for aircraft intended to operate under such conditions.

d) Yaw axis control power shall be adequate to develop ___ deg of sideslip in the power approach.

e) All carrier-based airplanes shall be capable of maintaining a straight path on the ground without the use of wheel brakes, at airspeeds of 30 knots and above, during takeoffs and landings in a 90-degree crosswind of at least 0.1 $V_S(L)$.

3.6.5.2 Yaw axis control power for two engines inoperative. At the one-engine-out speed for maximum range with any engine initially failed, upon failure of the most critical remaining engine the yaw control power shall be adequate to stop the transient motion and thereafter to maintain straight flight from that speed to the speed for maximum range with both engines failed. In addition, it shall be possible to effect a safe recovery at any service speed above $V_{o_{min}}$ (CL) following sudden simultaneous failure of the two critical engines.

3.6.5.3 Yaw axis control power with asymmetric loading. When initially trimmed directionally with each asymmetric loading specified in Paragraph 3.1.1 at any speed in the Operational Flight Envelope, yaw control power shall be sufficient to maintain a straight flight path.

3.6.5.4 Yaw axis control power for stores release. Yaw control power shall be adequate to regain straight flight, without retrimming, following intentional release of any stores to the maximum load factors specified in 3.2.8.2 with adequate control margin.

3.6.5.5 Yaw axis control power for other conditions. Control authority, rate and hinge moment capability shall be sufficient to assure safety throughout the combined range of all attainable angles of attack (both positive and negative) and sideslip. This requirement applies to the prevention of loss of control and to recovery from any situation for all maneuvering, including pertinent effects of factors such as regions of control-surface-fixed instability, inertial coupling, fuel slosh, the influence of symmetric and asymmetric stores, stall/post-stall/spin characteristics, atmospheric disturbances and Aircraft Failure States (maneuvering flight appropriate to the Failure State is to be included). Consideration shall be taken of the degrees of effectiveness and certainty of operation of limiters, c.g. control malfunction or mismanagement, and transients from failures in the propulsion, flight control and other relevant systems.

3.6.6 Yaw Axis Control Forces. Sensitivity to yaw control pedal forces shall be sufficiently high that directional control and force requirements can be met and satisfactory coordination can be achieved without unduly high control forces, yet sufficiently low that occasional improperly coordinated control inputs will not cause a degradation in flying qualities Level.

3.6.6.1 Yaw axis control force linearity. The following requirements are expressed in terms of characteristics in yaw-control-induced steady, zero-yaw-rate sideslips with the airplane trimmed for wings-level straight flight, at sideslip angles up to those produced or limited by:

a) Full yaw-control-pedal deflection, or

b) 250 pounds of yaw-control-pedal force, or

c) Maximum roll control or surface deflection,

except that for single-propeller-driven airplanes during waveoff (go-around), yaw-control-pedal deflection in the direction opposite to that required for wings-level straight flight need not be considered beyond the deflection for a 10-degree change in sideslip from the wings-level straight flight condition.

Right yaw-control-pedal force shall produce left sideslips and left yaw-control-pedal force shall produce right sideslips. For Levels 1 and 2 the following requirements shall apply. The variation of sideslip angle with yaw-control-pedal force shall be essentially linear for sideslip angles between ____ degrees and ____ degrees. Although a lightening of pedal force is acceptable for sideslip angles outside this range, the pedal force shall never reduce to zero.

3.6.6.2 Yaw axis control force limits

3.6.6.2.1 Yaw axis control force limits in rolling maneuvers. In the maneuvers described in 3.5.9, directional-control effectiveness shall be adequate to maintain zero sideslip with pedal force not greater than ___ lb.

3.6.6.2.2 Yaw axis control force limits in steady turns. It shall be possible to maintain steady coordinated turns in either direction, using ___ deg of bank with a pedal force not exceeding ___ lb, with the airplane trimmed for wings-level straight flight. These requirements constitute Levels 1 and 2.

3.6.6.2.3 Yaw axis control force limits during speed changes. When initially trimmed directionally with symmetric power, the trim change with speed shall be such that wings-level straight flight can be maintained over a speed range of ±30 percent of the trim speed or ±100 kt equivalent airspeed, whichever is less (except where limited by boundaries of the Service Flight Envelope) with yaw-control-pedal forces not greater than ___ lb without retrimming.

3.6.6.2.4 Yaw axis control force limits in crosswinds. It shall be possible to take off and land in the crosswinds specified in 3.6.3 without exceeding the following yaw control forces: _______________.

3.6.6.2.5 Yaw axis control force limits with asymmetric loading. When initially trimmed directionally with each asymmetric loading specified in Paragraph 3.1.1 at any speed in the Operational Flight Envelope, it shall be possible to maintain a straight flight path throughout the Operational Flight Envelope with yaw-control-pedal forces not greater than ___ lb without retrimming.

3.6.6.2.6 Yaw axis control force limits in dives and pullouts. Throughout the dives and pullouts of 3.2.9.7.3, yaw-control-pedal forces shall not exceed ____ lb in dives and pullouts to the maximum speeds specified in the Service Flight Envelope.

3.6.6.2.7 Yaw axis control force limits for go-around. The response to thrust, configuration and airspeed change shall be such that the pilot can maintain straight flight during go-around initiated at speeds down to V_S (PA) with yaw-control-pedal forces not exceeding ___ lb when trimmed at $V_{o_{min}}$ (PA). The preceding requirements apply for Levels 1 and 2. The Level 3 requirement is to maintain straight flight in these conditions with yaw-control-pedal forces not exceeding ___ lb. Bank angles up to 5 deg are permitted for all Levels.

3.6.6.2.8 Yaw axis control force limits for asymmetric thrust during takeoff.

a) During the takeoff ground run it shall be possible to achieve and maintain a straight path on the takeoff surface without a deviation of more than ___ ft from the path originally intended, with yaw-control forces not exceeding ___ lb.

b) For the continued takeoff it shall be possible, without a change in selected configuration, to achieve straight flight following sudden asymmetric loss of thrust from the most critical propulsive source at speeds from V_{min} (TO) to V_{max} (TO), and thereafter to maintain straight flight throughout the climbout without exceeding a maximum yaw control pedal force of ___ lb.

c) For the aborted takeoff the requirements above shall be met at all speeds below the maximum takeoff speed; however, additional controls such as nosewheel steering and differential braking may be used. Automatic devices that normally operate in the event of a thrust failure may be used in either case.

3.6.6.2.9 Yaw axis control force limits with failures. The change in yaw control force required to maintain constant heading following a failure shall not exceed ____ lb for at least 5 seconds following the failure.

3.6.6.2.10 Yaw axis control force limits — configuration or control mode change. The change in yaw control force required to maintain zero sideslip following intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall not exceed the following limits: ______________. These requirements apply only for Aircraft Normal States.

3.7 HANDLING QUALITY REQUIREMENTS FOR LATERAL FLIGHT PATH AXIS

3.7.1 Bandwidth Requirement for Lateral Translation

a) Dynamic response to direct force control input. The bandwidth of the open-loop response of lateral position to lateral translation control input shall be greater than _______ for Flight Phase ____. Lateral translations shall occur at essentially zero bank angle and zero change in heading.

b) Steady-state response to lateral translation control input. Maximum force control input shall produce at least ___ degrees of sideslip.

c) Lateral translation control forces and deflections. Use of the primary lateral translation control shall not require use of another control manipulator to meet Requirement a). The controller characteristics shall meet the following requirements: ______________.

d) Pilot accelerations. Abrupt, large control inputs shall not produce pilot head or arm motions which interfere with task performance. Pilot restraints shall not obstruct the crew's normal field of view nor interfere with manipulation of any cockpit control required for task performance.

3.8 HANDLING QUALITY REQUIREMENTS FOR COMBINED AXES

3.8.1 Cross-Axis Coupling in Roll Maneuvers. In yaw-control-free, pitch-control-fixed, maximum-performance rolls through ____ deg, entered from straight flight or from turns, pushovers, or pullups ranging from 0 g to 0.8 n_L, the resulting yaw or pitch motions and sideslip or angle of attack changes shall neither exceed structural limits nor cause other dangerous flight conditions such as uncontrollable motions or roll autorotation.

During combat-type maneuvers involving rolls through angles up to 360 degrees and rolls which are checked at a given bank angle, the yawing and pitching shall not be so severe as to impair the tactical effectiveness of the maneuver. These requirements define Level 1 and 2 operation. For Class II and III airplanes, these requirements apply in rolls through 120 degrees and rolls which are checked at a given bank angle.

3.8.2 Crosstalk Between Pitch and Roll Controllers. The pitch- and roll-control force and displacement sensitivities and breakout forces shall be compatible so that intentional inputs to one control axis will not cause inadvertent inputs to the other.

3.8.3 Control Harmony. The following control force levels are considered to be limiting values compatible with the pilot's capability to apply simultaneous forces: ______________.

3.8.4 Flight at High Angle of Attack. The requirements of 3.8.4 through 3.8.4.3.2 concern stall warning, stalls, departures from controlled flight, post-stall gyrations, spins, recoveries, and related characteristics. They apply at speeds and angles of attack which in general are outside the Service Flight Envelope. They are intended to assure safety and the absence of mission limitations due to high angle-of-attack characteristics.

3.8.4.1 Warning cues. Warning or indication of approach to stall, loss of aircraft control, and incipient spin shall be clear and unambiguous.

3.8.4.2 Stalls. The stall requirements apply for all Aircraft Normal States in straight unaccelerated flight and in turns and pullups with attainable normal accelerations up to n_L. Specifically, the Aircraft Normal States to be evaluated are: ____________________. Also, the requirements apply to Aircraft Failure States that affect stall characteristics.

3.8.4.2.1 Stall approach

a) The onset of warning of stall approach (3.8.4.1) shall occur within the following speed range for 1 g stalls: ____, and within the following range (or percentage) of lift for accelerated stalls: ____________, but not within the Operational Flight Envelope.

b) An increase in intensity of the warning with further increase in angle of attack shall be sufficiently marked to be noted by the pilot. The warning shall continue until the angle of attack is reduced to a value less than that for warning onset. Prior to the stall, uncommanded oscillations shall not result in flying qualities less than Level ___.

c) At all angles of attack up to the stall, the cockpit controls shall remain effective in their normal sense, and small control inputs shall not result in departure from controlled flight.

3.8.4.2.2 Stall characteristics. The following apply for all stalls, including stalls entered abruptly:

a) In the unaccelerated stalls of 3.8.4.2.1, the airplane shall not exhibit rolling, yawing, or downward pitching at the stall which cannot be controlled to stay within ___ deg.

b) It is desired that no pitchup tendencies occur in unaccelerated or accelerated stalls. However, in unaccelerated stalls, mild nose-up pitch may be acceptable if no pitch control force reversal occurs and if no dangerous, unrecoverable or objectionable flight conditions result. In accelerated stalls, mild nose-up tendency may be acceptable if the operational effectiveness of the airplane is not compromised and the airplane has adequate stall warning, pitch control effectiveness is such that it is possible to stop the pitchup promptly and reduce the angle of attack, and at no point during the stall, stall approach or recovery does any portion of the airplane exceed structural limit loads.

3.8.4.2.3 <u>Stall prevention and recovery</u>.

a) It shall be possible to prevent the stall by moderate use of the pitch control alone at the onset of the stall warning.

b) It shall be possible to recover from a stall by simple use of the pitch, roll, and yaw controls with cockpit control forces not to exceed ______, and to regain level flight without excessive loss of altitude or buildup of speed. Throttles shall remain fixed until an angle of attack below the stall has been regained unless compliance would result in exceeding engine operating limitations.

c) In the straight flight stalls of 3.8.4.2, with the aircraft trimmed at an airspeed not greater than 1.4 V_s, pitch control power shall be sufficient to recover from any attainable angle of attack.

3.8.4.2.4 <u>One-engine-out stalls</u>. On multi-engine aircraft it shall be possible to recover safely from stalls with the critical engine inoperative. Thrust on the remaining engines will be at: __________.

3.8.4.3 <u>Departures and Spins</u>. The post-stall gyration and spin requirements apply to all modes of motion that can be entered from upsets, decelerations, and extreme maneuvers appropriate to the Class and Flight Phase Category. The requirements hold for all Aircraft Normal States and for all states of stability and control augmentation systems, except approved Special Failure States. Store release shall not be allowed during loss of control, spin or gyration, recovery, or subsequent dive pullout. Automatic disengagement of augmentation systems, however, is permissible if it is necessary and does not prevent meeting any other requirements; re-engagement shall be possible in flight following recovery. Specific flight conditions to be evaluated are: ____________________.

3.8.4.3.1 <u>Departure from controlled flight</u>. The aircraft shall be resistant to departure from controlled flight, post-stall gyrations and spins. Adequate warning of approach to departure (3.8.4.1) shall be provided. The airplane shall exhibit no uncommanded motion which cannot be arrested promptly by <u>simple</u> application of pilot control.

3.8.4.3.2 <u>Recovery from post-stall gyrations and spins</u>. For aircraft that, according to MIL-A-8861, must be structurally designed for spinning:

a) The proper recovery technique(s) must be readily ascertained by the pilot, and simple and easy to apply under the motions encountered.

b) A single technique shall provide prompt recovery from all post-stall gyrations and incipient spins, without requiring the pilot to determine the direction of motion

and without tendency to develop a spin. The same technique used to recover from post-stall gyrations and incipient spins, or at least a compatible one, is also desired for spin recovery. For all modes of spin that can occur, these recoveries shall be attainable within: ________________________.

c) Avoidance of a spin reversal or an adverse mode change shall not depend upon precise pilot control timing or deflection. It is desired that all airplanes be readily recoverable from all attainable attitudes and motions. The post-stall characteristics of those aircraft not required to comply with requirements of this paragraph shall be determined by analysis and model test.

d) Safe and consistent recovery and pullouts shall be accomplished without exceeding the following forces: _______________, and without exceeding structural limitations.

3.9 HANDLING QUALITY REQUIREMENTS IN ATMOSPHERIC DISTURBANCES

3.9.1 <u>Allowable Handling Qualities Degradations in Atmospheric Disturbances</u>. Level ___ flying qualities are required for atmospheric disturbance levels up to and including _______________________________ and wind shears of magnitude _____________________.

3.9.2 <u>Definition of Atmospheric Disturbance Model Form</u>. When compliance via demonstration is to be carried out using piloted simulation, an atmospheric disturbance model appropriate to the piloting task shall be included. As a minimum, the atmospheric disturbance model shall consist of _______________.

3.9.3 <u>Application of Disturbance Models in Analyses</u>. The gust and turbulence velocities shall be applied to the airplane equations of motion through the aerodynamic terms only, and the direct effect on the aerodynamic sensors shall be included when such sensors are part of the airplane augmentation system. Application of the disturbance model depends on the range of frequencies of concern in the analyses of the airframe. When structural modes are significant, the exact distribution of turbulence velocities should be considered. For this purpose, it is acceptable to consider u_g and v_g as being one-dimensional, a function of both x and y, for the evaluation of aerodynamic forces and moments.

When structural modes are not significant, airframe rigid-body responses may be evaluated by considering uniform gust or turbulence immersion along with linear gradients of the disturbance velocities. The uniform immersion is accounted for by u_g, v_g, and w_g defined at the airplane center of gravity. The angular velocities due to turbulence are equivalent in effect to airplane angular velocities. Approximations for these angular velocities are defined (precise only at very low frequencies) as follows:

$$-\dot{\alpha}_g = q_g = \frac{\partial w_g}{\partial x} \quad , \quad p_g = -\frac{\partial w_g}{\partial y} \quad , \quad r_g = -\frac{\partial v_g}{\partial x}$$

The spectra of the angular velocity disturbances due to turbulence are given in Paragraph 3.9.2.

For altitudes below 175 ft, the turbulence velocity components u_g, v_g, and w_g are to be taken along axes corresponding to u_g aligned along the relative mean wind vector and w_g vertical.

3.9.4 Requirements for Aircraft Failure States in Atmospheric Disturbances. When Aircraft Failure States exist (3.1.6), a degradation in flying qualities is permitted only if the probability of encountering a lower Level than specified in 3.9.1 is sufficiently small. At intervals established by the procuring activity, the contractor shall determine, based on the most accurate available data, the probability of occurrence of each Aircraft Failure State per flight and the effect of that Failure State on the flying qualities within the Operational and Service Flight Envelopes. These determinations shall be based on MIL-STD-756 except that:

a) All airplane components and systems are assumed to be operating for a time period, per flight, equal to the longest operational mission time to be considered by the contractor in designing the airplane, and

b) Each specific failure is assumed to be present at whichever point in the Flight Envelope being considered is most critical (in the flying qualities sense).

From these Failure State probabilities and effects, the contractor shall determine the overall probability, per flight, that one or more flying qualities are degraded to Level 2 because of one or more failures. The contractor shall also determine the probability that one or more flying qualities are degraded to Level 3.

3.9.4 Requirements for Aircraft Failure States in Atmospheric Disturbances [Alternate Requirement]. Failure States shall be evaluated in moderate levels of atmospheric disturbance.

a) A Level 2 aircraft shall not degrade below Level 3 in the presence of failures and moderate atmospheric disturbances.

b) A Level 3 aircraft shall have flying qualities in the presence of failures and moderate atmospheric disturbances such that control can be maintained long enough to fly out of the disturbance.

SECTION 4

4. NOTES

Refer to the MIL Handbook for all applicable Notes on Intended Use, Definitions, Gain Scheduling, Engine Considerations, and Effects of Aeroelasticity, Control Equipment, and Structural Dynamics.